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[Continued on next page]

(54) Title: A METHOD OF ESTIMATING THE LOAD ON A CHANNEL WITHIN A CELL OF A MOBILE TELECOMMUNICATIONS SYSTEM
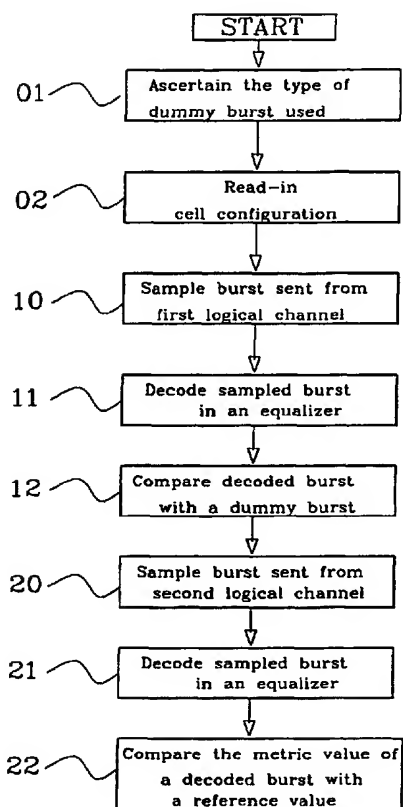
(57) Abstract: The present invention relates to a method of estimating the load on a channel within a cell (C1) of a mobile telecommunications system, in which load estimation is effected in a radio unit (MS2) situated in a point that is covered by the specific cell (C1). The load is estimated by calculating the number of free time slots, which are counted by examining different channels and looking for certain bit patterns that indicate that dummy bursts have been sent instead of speech/data traffic. The discovery of a dummy burst is indicative of free capacity. Because the invention can be carried out in a radio unit (MS2) that is situated in the cell (C1), load can be measured without requiring access to the network. The invention thus enables load to be measured in any cell whatsoever and from anywhere in the cell. The invention also makes it unnecessary to generate test data in the network.

WO 01/91495 A1

WO 01/91495 A1

A method of estimating the load on a channel within a
cell of a mobile telecommunications system

FIELD OF INVENTION

The present invention relates to the field of mobile telecommunications systems. More

specifically, the invention relates to a method of estimating the load on a channel in a

cellular mobile telecommunications system.

The invention relates particularly, but not exclusively, to a method of estimating the

load on a traffic channel in a mobile telecommunications system of the GSM-type,

GSM = Global System for Mobile Communication. The invention can also be applied

to GSM together with GRPS (General Packet Radio Service) and/or EDGE (Enhanced

Data Rates for Global Evolution), and to other mobile telecommunications systems

based on TDMA.

DESCRIPTION OF THE BACKGROUND ART

In a digital mobile telecommunications system that utilises TDMA, information is

transmitted during certain time slots in a sequence of frames between radio nodes and

one or more mobiles, where payload information may consist of speech information in

a speech connection, or data information in a data connection. Moreover, transmitted

information may consist of control and synchronisation information that is sent over

the speech/data channel or over special channels intended for this purpose, so-called

control channels.

The channel structure for the aforesaid TDMA-system includes logic control channels

over which control signals are sent between radio nodes and mobiles, and a logic traf-

fic channel TCH over which payload signals (speech and/or data) are transmitted. In

turn, the control channel CCH is comprised of a number of special control channels,

such as the broadcast channel BCH for example. The aforesaid channel structure also includes channels used for packet data.

It is known to count the number of occupied time slots in order to determine load on a channel in a cell; see for instance PCT-application WO9833344.

SUMMARY OF THE INVENTION

One problem encountered in GSM-type mobile telecommunications systems is that cell traffic recordings effected with the purpose of measuring the load in a cell are performed on the network side and must be initiated manually. This can not be carried out constantly, since it generates a large amount of data that interferes with the traffic and loads the network side. The problem is also applicable to GSM with data traffic (GPRS) and high rate modulation in respect of GSM (EDGE).

One object of the present invention is to enable the load in a cell to be measured with the aid of any mobile terminal whatsoever in the cell, without needing to make adjustments on the network side.

Another object of the present invention is to enable the load in those cells that cover the point where the measuring equipment is located to be estimated.

According to the invention, the number of free or unoccupied time slots are counted by searching on a control channel for known bit patterns of dummy bursts sent in free time slots, and measuring the metric value of the training sequence on a traffic channel and comparing this value with a threshold value.

One advantage afforded by the invention is that the load on a channel in a cellular mobile telecommunications system can be measured more easily, since it is not necessary to generate test data in the network.

Another advantage is that the measurement can be carried out on several cells, i.e. cells which cover the point in question where the measuring equipment is located, instead of on the network side.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail with reference to preferred embodiments thereof and also with reference to the accompanying drawings, in which

Figure 1 illustrates part of a cellular mobile telecommunications system, including mobiles and radio nodes;

Figure 2 illustrates the channel structure over the air interface for a GSM-system that includes packet additions;

Figure 3 illustrates a typical cell configuration with four carrier waves and non-combined SDCCH;

Figure 4 illustrates the appearance of a normal burst;

Figure 5 is a schematic illustration of an equalizer; and

Figure 6 is a flowchart illustrating one embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The method according to the invention is intended for a mobile telecommunications system of the GSM-type, or GSM with data traffic (GPRS) and/or high rate modulation for GSM (EDGE). GPRS is a data service that changes from circuit switching to packet switching, which increases the rate of data transmission by allowing a user to use more time slots in a frame, and as a result of changing channel coding in relation to current interference levels. EDGE is a modulation technique that gives higher rates and that utilises the same TDMA-frame structure, logic channels and 200kHz carrier waves as GSM.

An inventive system is intended to include one or more radio nodes and one or more mobiles that communicate with each other over a given radio channel.

Figure 1 shows part of one such system, which includes the radio node BTS1 that covers the cell C1 in which the mobiles MS1 and MS2 are situated. Transmission between radio nodes and mobiles is effected with the aid of time slots. In a GSM-type system, each carrier is allocated an ARFCN (Absolute Radio Frequency Channel Number), and each ARFCN is divided into eight time slots, in other words eight time slots are used for each carrier, meaning that up to eight mobiles are able to use the same carrier wave by using different time slots. A time slot on an ARFCN is called a physical channel and information transmitted in a time slot is called a burst. An arrangement according to the invention can thus be situated in the mobile MS2.

Figure 2 illustrates the structure of logic channels over the air interface of the GSM-system. The channel structure includes control channels over which control signals are transmitted between radio nodes and mobiles. The structure also includes a traffic channel TCH over which payload signals (speech and/or data) are transmitted. As will be evident from Figure 2, the control channel CCH includes a number of special control channels, for instance the broadcast channel BCH, which, in turn, consists of the frequency correction channel FCCH, the synchronisation channel SCH, and the broadcast control channel BCCH. The control channel CCH also includes a dedicated control channel, DCCH, which, in turn, includes a stand alone dedicated control channel, SDCCH. The channel structure also includes packet data channels, for instance PDCCH, PCCCH, DCCH and PDTCH.

The actual traffic channel TCH and the aforesaid control channels are particularly involved in the estimation of the load on a channel in accordance with the invention. Each special control channel, e.g. BCH, SDCCH, DCCH, PDCCH and PCCCH may also be concerned in this estimation in different embodiments of the invention, and also the packet data channel PDTCH.

Figure 3 illustrates a typical variant of a cell configuration that is set-up by each operator, this variant including four carriers C1-C4 and non-combined SDCCH. That this latter channel is non-combined means that in the illustrated case only SDCCH is present in time slot T1 on carrier C1, as compared with a combined SDCCH where the control channel SDCCH may be combined with other control channels, for instance with BCCH and/or CCCH, in one and the same time slot. In the illustrated case, the broadcast channel BCH occupies the first time slot TO in the first carrier CO and the dedicated control channel SDCCH occupies the second time slot T1. The remaining time slots are occupied by the traffic channel TCH.

As earlier mentioned, the information sent in a time slot is called a burst. Figure 4 illustrates the appearance of one type of burst, in the illustrated case a so-called normal burst used for standard payload data transmission. The two traffic data fields TD1, TD2 consist of 57 bits, each containing encrypted data or speech, and one bit that indicates whether or not the burst has been borrowed for FACCH signalling. The training sequence TS is a known bit pattern that is used to create a channel model. The training sequence TS is placed in the centre of the burst, because it is assumed that the channel is constant during the full duration of the burst and is thereby influenced in the same way through the whole of the burst. By using this placement of the training sequence, it is more likely that the radio transmission over the channel will not be any different when it influences the training sequence TS than when it influences the information bits TD1 and TD2. Any other placement, e.g. at the beginning of the burst, may possibly result in a channel model that is incorrectly created with respect to the bits at the end of the burst. These tail bits TB are always 000, and are used for the equaliser, which requires a known start- and –stop pattern or configuration.

In order to ascertain what has actually been transmitted in the air interface, a received burst is taken into an equaliser and a mathematical model is created for calculating the data most likely to have been transmitted. Figure 5 illustrates a model of an equaliser, in this case a Viterbi equaliser. Other equalisers may alternatively be used, for instance

an MLSE (Maximum Likelihood Sequence Estimator). It has been said in the afore-going that a pre-determined training sequence TS is transmitted in the centre of each burst. The equaliser creates a channel model, by comparing this training sequence TS with the bit pattern TS' received. A likely transmitted bit sequence is then fed through the channel model and the result compared with the received bit sequence. The equaliser then examines the difference between these two bursts and chooses a most likely transmitted bit sequence. According to a pre-given mathematical model that places certain requirements on the equaliser and its result, this examination is repeated until the result is satisfactory and the equaliser fulfils said requirements.

Figure 6 is a flowchart illustrating one embodiment of the present invention. According to this embodiment, dummy bursts (i.e. bursts that contain no information) are used to find and calculate the number of free time slots.

The first step 01 includes ascertaining the type of dummy bursts that have been sent in free time slots within the above specified area, and also to ascertain whether or not DTX (Discontinuous Transmission) has been used within said area. If it becomes quiet in a given time during a call, DTX is coupled in, meaning that comfort noise is applied so as to prevent queer sounds in the receiver. When this takes place, only a few bursts that contain a description of the noise characteristic in the source signal are transmitted instead of the number of bursts that are normally sent. In GSM for instance, DTX re-duces the number of transmitted bursts to 12 instead of 104, this latter number being the number normally sent.

The aforedescribed dummy bursts are required since the output power from a radio node must be constant on the first carrier, so that mobiles in an idle mode can find the bursts, and in order to be able to measure in those neighbouring cells that also cover the point in which respective mobiles are situated, possibly in order to find the cell that provides better quality with respect to the radio transmission. According to the GSM-

specification 05.02, four different bursts can be used for transmission on free time slots.

The first is a dummy burst having the same training sequence as a normal burst;

The second is a dummy burst that has a special training sequence;

The third is a dummy burst that has the same training sequence as a normal burst. For instance, if the training sequence normally used is training sequence number 1 then training sequence number 5 is used instead;

The fourth burst comprises parts of the SID-information given by the speech encoder, this fourth burst variant being used together with DTX and detected thereby.

The second step 02 includes reading-in the cell configuration found in a first time slot T0 in a first carrier C0. This involves finding out the number of time slots used for the traffic channel TCH on C0, and the total number of carriers used in this carrier. The number of time slots used by the traffic channel TCH can be found by looking at the channel configuration, combined or non-combined SDCCH. If combined SDCCH channel configuration is used, this is a strong indication that all remaining time slots are used as traffic channels TCH. The number of carriers used is obtained from the allocation list of the cell.

The third step 10 involves sampling the burst set from the radio node, for all carriers on a first logic channel, for example CCH. Sampling involves measuring the analogue signal that has a given frequency and that corresponds to a certain channel, at certain time points. Each value is called a sample and measurements are repeated at defined time intervals, so-called sampling time Ts. Just how well the analogue signal can be described digitally, will depend, among other things, on how often the signal is sam-

pled. This is described as the sampling frequency 1/Ts. In one embodiment of the present invention, sampling takes place at the frequency 270.83 kHz for instance.

There then follows the fourth step 11, which includes the encoding of sampled bursts in an equaliser, which involves the sampled burst from the preceding step 10 being processed in the equaliser in order to obtain the most likely transmitted bit pattern.

In the fifth step 12, a decoded burst is compared with the type of dummy burst used in the current specific area to discover an unused time slot. In this case, a comparison is made against one of the aforesaid alternatives for filling a free time slot. In one embodiment of the invention, there is compared a first TD1 and a second data field TD2 (see Figure 4) in the decoded burst from a bit pattern for the pre-defined dummy burst described in standard GSM 05.02, such as to discover an unused time slot.

I another embodiment of the invention there is used a dummy burst that has a special training sequence, or a dummy burst that has the same training sequence as a normal burst but which is mapped differently in order to fill up free time slots. As before mentioned, the mapping is done differently, in so much that when, e.g., training sequence number 1 of eight possible training sequences is normally used, there is used in this case training sequence number 5 instead. The sampled burst is then processed in the equaliser with the aid of the same training sequence as that used for a normal burst, which results in the discovery of an unused time slot by virtue of the metric value for the training sequence (TS) from the equaliser being the highest possible value. The metric value is a value that is obtained from the equaliser and that derives from the training sequence. The metric value becomes greater with increasing differences between the known training sequence and the received training sequence. An anticipated low value is not obtained when the training sequence from a dummy burst is processed in the equaliser. This is because the equaliser endeavours to decode the dummy burst as though it were a normal burst. As a result, the metric value of a dummy burst will be the highest possible value.

A third embodiment involves the use of DTX. When DTX is used, only a few bursts are sent, for instance 12 bursts as in GSM, instead of the number of bursts that are normally sent during a call connection, for instance 104 bursts in the case of GSM. This means that it is only possible to look at the few bursts that are sent, in order to discover an occupied time slot.

The sixth step 20 in Figure 6 involves sampling the burst sent from the radio node, for all carriers on a second logic channel, e.g. TCH.

The seventh step 21 involves decoding sample bursts in an equaliser, wherein the sampled burst from the preceding step 20 is processed in the equaliser in order to obtain the most likely transmitted bit pattern.

The eighth step 22 involves a comparison of the metric value of the decoded burst for the training sequence with a threshold value, in order to thereby discover an unused time slot. An unused time slot is discovered by virtue of the metric value being greater than the threshold value, since the metric value becomes greater with increasing differences between received training sequences and the known training sequence.

It will be understood that the invention is not restricted to the aforedescribed and illustrated exemplifying embodiments thereof, and that modifications can be made within the scope of the accompanying claims.

CLAIMS

1. A method of estimating the load on a channel within a specific area (C1) in a mobile telecommunications system that includes at least one radio node (BTS1) adapted for communication with mobiles (MS1, MS2), wherein said load is estimated in a radio unit (MS2) situated within said specific area (C1), and by calculating the number of occupied time slots in each carrier (CO, C1,...), which number can then represent the load on said channel and wherein the method comprises the steps of:

- ascertaining (01) the type of dummy bursts sent in free or unoccupied time slots within the aforesaid specific area;

- reading-in (02) the cell configuration from a first time slot (T0) in a first carrier (C0),

- and wherein in respect of all carriers on a first logic channel the method comprises the further steps of

- sampling (10) a burst transmitted from a radio node (BTS1);

- decoding (11) the sampled burst;

- comparing (12) the decoded burst with that type of dummy burst used in the specific area (C1) concerned, so as to discover an unused time slot;

and in respect of all carriers on a second logic channel comprises the further steps of

- sampling (20) a burst sent from a radio node (BTS1);

- decoding (21) the sampled burst in an equaliser;

and comparing (22) the metric value of the decoded burst in respect of the training sequence with a threshold value such as to discover an unused time slot.

2. A method according to Claim 1, **characterized in** that said first logic channel is a control channel (CCH).

3. A method according to any one of Claims 1-2, **characterized in** that said second logic channel is a traffic channel (TCH).

4. A method according to any one of Claims 1-3, **characterized in** that said mobile telecommunications system is a system of the type, GSM, GSM with GPRS, GSM with EDGE or GSM with EDGE and GPRS.

5. A method according to any one of Claims 1-4, **characterized in** that when using in said specific area (C1) a dummy burst having the same training sequence (TS) as that used for a normal burst in order to fill up free time slots, a first data field (TD1) and a second data field (TD2) in the decoded burst from a first logic channel (CCH) is compared with the bit pattern for the pre-defined dummy burst described in the standard description GSM 05.02, such as to discover an unused time slot.

6. A method according to any one of Claims 1-4, **characterized in** that when there is used in said specific area (C1) a dummy burst having a special training sequence or a dummy burst having the same training sequence as that used for a normal burst but mapped differently in order to fill up free time slots, the aforesaid sampled burst from a first logic channel (CCH) is processed in the equaliser with the aid of the same training sequence as that used for a normal burst, and an unused time slot is discovered by virtue of the metric value of the training sequence (TS) from the equaliser being the highest possible value.

7. A method according to any one of Claims 1-6, **characterized in** that the first step (01) also includes ascertaining whether or not additional noise is used within the aforesaid specific area upon interruption of transmission (DTX).

8. A method according to Claim 7, **characterized in** that when bursts that contain a description of the characteristic of the noise in the source signal are used in the event of interrupted transmission (DTX) in the specific area (C1) concerned, only those bursts that include a description of the noise characteristic that are sent to discover an occupied time slot are examined.

9. A method according to any one of Claims 1-8, **characterized in** that said decoding is effected in a Viterbi-type equaliser.

10. A method according to any one of Claims 1-8, **characterized in** that said decoding is effected in an equaliser of the MLSE-type (Maximum Likelihood Sequence Estimator).

11. A radio unit for estimating the load on a channel within a specific area (C1) of a mobile telecommunications system, comprising at least one radio node (BTS1) adapted to communicate with mobiles (MS1, MS2), wherein said estimation is effected by calculating the number of occupied time slots in each carrier (C0, C1...) which can then represent the load on the channel, including means for determining which type of dummy bursts are used, and means for reading-in the cell configuration of the specific area in question, **characterized in** that the radio unit further includes means for sampling a first transmitted on a first logic channel, means for decoding said sampled burst, means for comparing said decoded burst with a previously known dummy burst, and means for sampling a first transmitted on a second logic channel, means for decoding said burst, and means for comparing the metric value of a decoded burst in respect of the training sequence (TS) with a threshold value.

12. A radio unit according to Claim 11, **characterized in** that the radio unit also includes means for determining whether or not noise was used during a call in the specific area (C1) upon interrupted transmission (DTX).

13. A radio unit according to any one of Claims 11-12, **characterized in** that said burst decoding means is a Viterbi-type equaliser.

14. A radio unit according to any one of Claims 11-12, **characterized in** that said burst decoding means is an equaliser of the type MLSE (Maximum Likelihood Sequence Estimator).

Fig.1

Logical channels

Control channel
CCH

Traffic channel
TCH

Half
rate

Full
rate

Packet
PDTCH

PDCCH

PACCH   PTCCH

PCCCH

BCH   CCCH

PRACH   PPCH   PAGCH

RACH

PCH

AGCH

FCCH

PBCCH

SCH   BCCH

DCCH

SDCCH   SACCH   FACCH
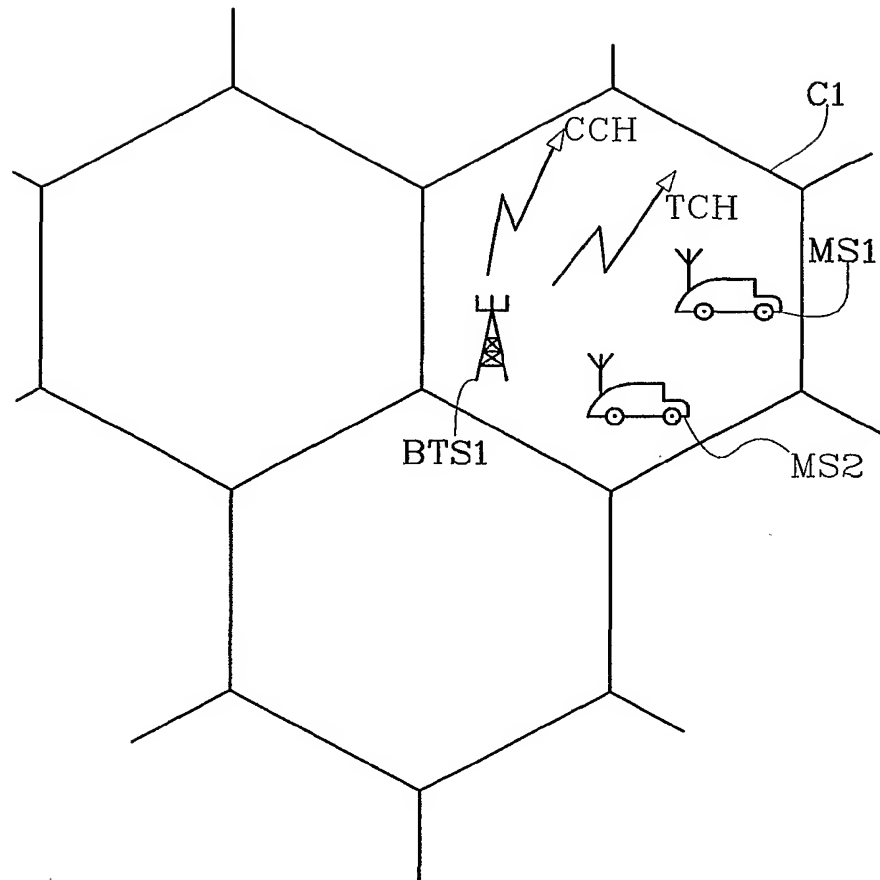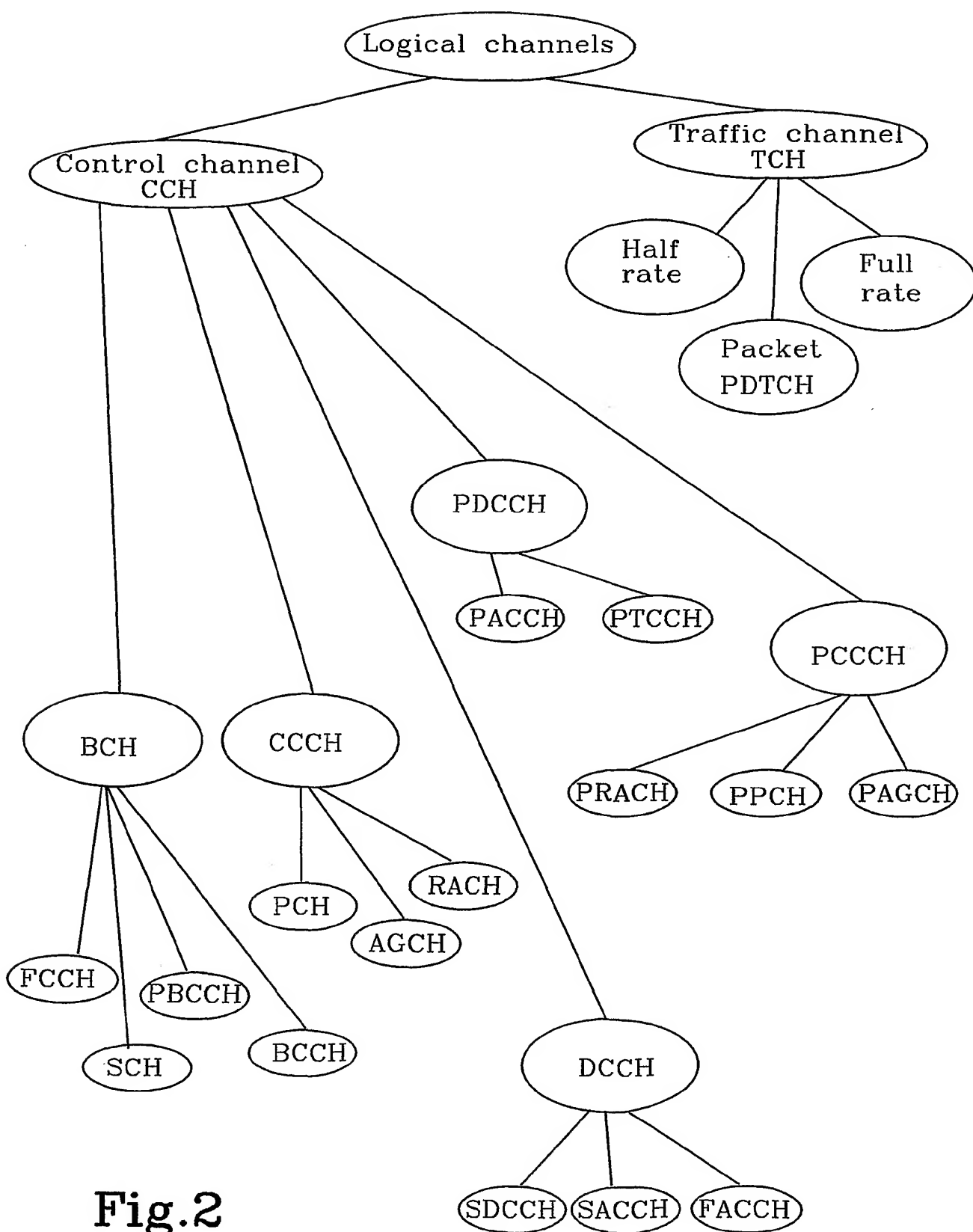
Fig.2

	T0	T1	T2	T3	T4	T5	T6	T7
C3	TCH	TCH	TCH	TCH	TCH	TCH	TCH	TCH
C2	TCH	TCH	TCH	TCH	TCH	TCH	TCH	TCH
C1	TCH	TCH	TCH	TCH	TCH	TCH	TCH	TCH
C0	BCH	SDCCH	TCH	TCH	TCH	TCH	TCH	TCH

Fig.3
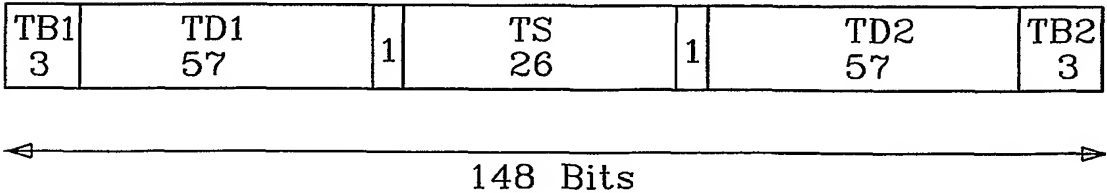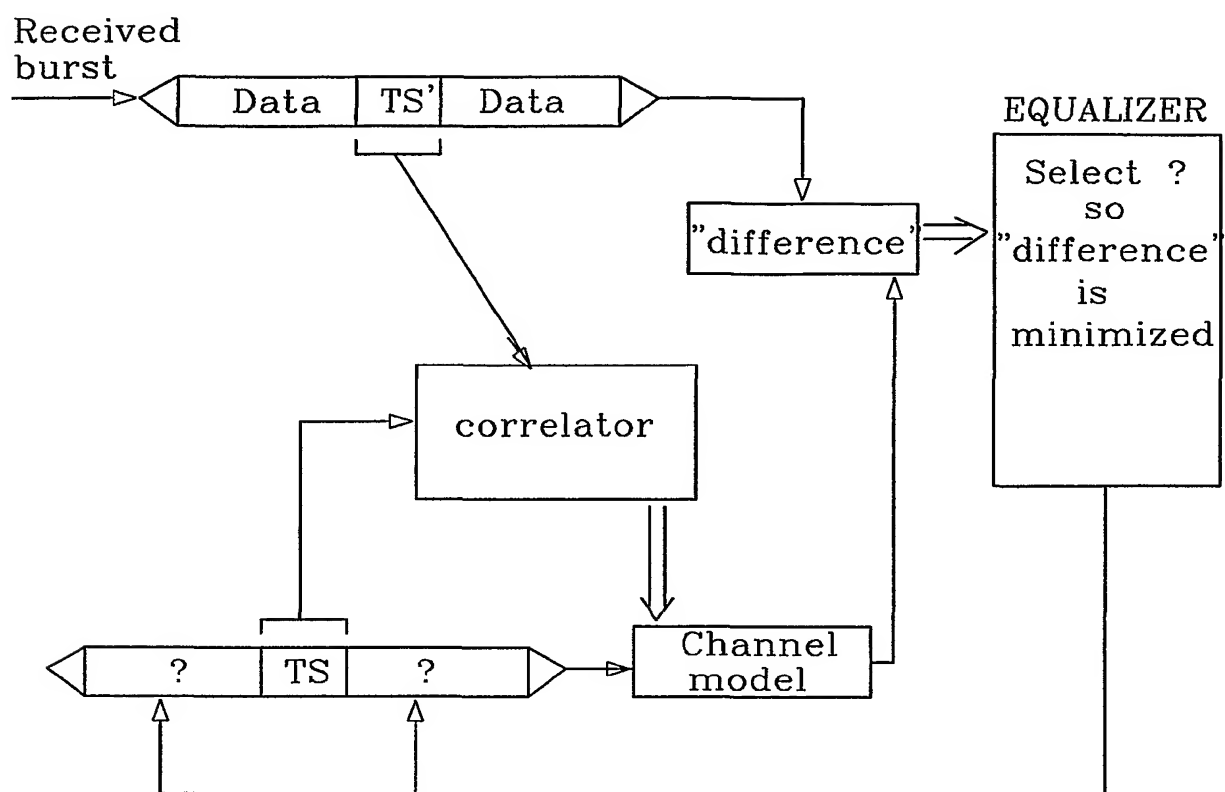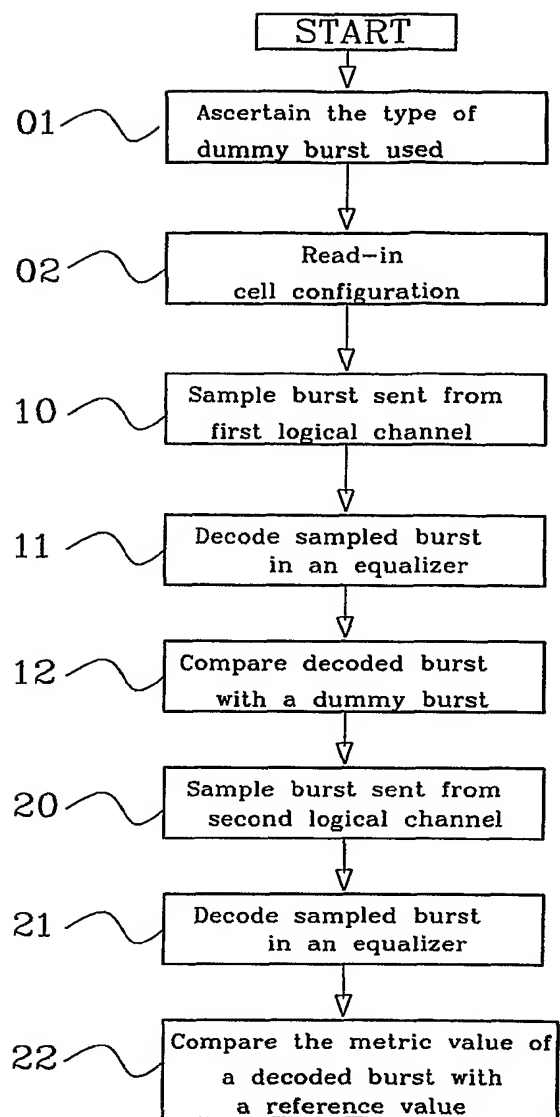
TB1 3	TD1 57	1	TS 26	1	TD2 57	TB2 3

$\longleftarrow$ 148 Bits $\longrightarrow$

Fig.4

4/5

Fig.5

5/5

```
              ┌──────────────┐
              │    START     │
              └──────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
01 ─────│   Ascertain  the  type  of  │
        │     dummy  burst  used      │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
02 ─────│          Read−in            │
        │     cell  configuration     │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
10 ─────│   Sample  burst  sent  from │
        │     first  logical  channel │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
11 ─────│     Decode  sampled  burst  │
        │       in  an  equalizer     │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
12 ─────│   Compare  decoded  burst   │
        │     with  a  dummy  burst   │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
20 ─────│   Sample  burst  sent  from │
        │    second  logical  channel │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
21 ─────│     Decode  sampled  burst  │
        │       in  an  equalizer     │
        └─────────────────────────────┘
                      │
                      ▽
        ┌─────────────────────────────┐
22 ─────│ Compare  the  metric  value of│
        │   a  decoded  burst  with   │
        │      a  reference  value    │
        └─────────────────────────────┘
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Fig.6

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04Q 7/32
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9624200 A1 (NOKIA MOBILE PHONES LTD), 8 August 1996 (08.08.96), page 1, line 1 - page 9, line 10, abstract	1-14
A	WO 9833344 A1 (SINGAPORE TELECOM MOBILE PTE LTD), 30 July 1998 (30.07.98), page 1, line 1 - page 4, line 30, abstract	1-14
A	DE 4413484 A1 (ROHDE & SCHWARZ GMBH & CO KG), 26 October 1995 (26.10.95), abstract	1-14

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O"	document referring to an oral disclosure, use, exhibition or other means	"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"P"	document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 August 2001	2 7 -08- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Thomas Tholin/js Telephone No. + 46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

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				FI	2191	U	21/11/95
				FI	99066	B,C	13/06/97
				FI	950419	A,V	01/08/96
				FR	2730117	A,B	02/08/96
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				GB	9525966	D	00/00/00
				JP	10513318	T	15/12/98
				NL	1001927	A,C	00/00/00
				SE	506999	C	16/03/98
				SE	9504541	A	01/08/96
				US	6038238	A	14/03/00
WO	9833344	A1	30/07/98	GB	2337182	A,B	10/11/99
				GB	9917752	D	00/00/00
DE	4413484	A1	26/10/95	NONE			